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RESEARCH PAPER

Socio-Economic Characteristics and Fishing Operation Activities of the Artisanal Fishers in the Sundarbans Mangrove Forest, Bangladesh

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Abstract

The Sundarbans Mangrove Forest (SMF) is a complex ecosystem containing the most diverse and abundant natural resources of Bangladesh. The research was designed to investigate the socio-economic characteristics and fishing operation activities of the artisanal fishers in the SMF through case studies. Despite the great importance of mangroves in the livelihood of the artisanal fishermen in the SMF, deforestation is perceived to continue due to illegal logging and deterioration of mangroves for climate change, increased salinity, natural disasters, shrimp farming and household consumption. The consequences are depleted fish and fishery resources, changes in fisher's primary occupation and livelihood status. The present study also elicited several risks and shocks of the fishermen livelihood like the attack by dacoits, hostage, ransom, and attack by tigers, natural disasters, river bank erosion. However, the artisanal fishermen adopted different strategies to cope with the changing conditions by forming associations, violating the fisheries laws and regulations, migrating, sharing responsibilities with the household members, and transmitting local ecological knowledge. This study concludes that there is an urgency to update the existing policies and management issues for the sustainable extraction of the SMF resources for the improvement of the artisanal fishermen livelihood.

Keywords: The Sundarbans Mangrove Forest, artisanal fishery, fishing operations, socio-economic condition.

Introduction

General Description of Artisanal Fisheries

Artisanal fisheries are small-scale fisheries where fishers use traditional fishing techniques and small boats for the sake of subsistence living and to meet the demands of small local markets (Freire & García, 2000). The term is used interchangeably with the 'small scale fishery,' and sometimes considered as a subset of 'small scale' (Demuynck, 1994). The artisanal fisheries, particularly in developing nations, are vital to livelihoods and food security to local communities. In comparison, artisanal and commercial fisheries amass the similar amount of fishes for human consumption (30 million tons), yet small-scale fisheries employ 25 times the number of fishers (over 12 million people) and use an eighth of the amount of fuel used by industrial fisheries (Jacquet & Pauly, 2008). The general characteristics of artisanal fisheries are: use of a relatively simple technology, labor-intensive, small groups of operators, low capital inputs, marketing and distribution handled by powerful intermediaries' external to genuine fishers, and fishing communities suffer from poor physical infrastructure and living conditions (Seki & Bonzon, 1993). Fishing activity of artisanal fishers cannot be judged separately from their social organizations that are primarily determined by the type of water bodies they fish in. The ideal water bodies are seas, lagoons or inland bodies (Demuynck, 1994). Understanding and reducing the impacts of artisanal fisheries on marine ecosystems is a rapidly emerging priority for marine conservation. In the context of degrading ecosystems, increasing fishing effort and ever-growing human populations, there is urgent need to develop sustainable management strategies for artisanal fisheries (Johnson *et al*., 2013).

Fishery Resources in the Sundarbans Mangrove Forest

The Sundarbans Mangrove Forest (SMF), a world heritage site and the largest mangrove forests in the world, shared between Bangladesh (62%) and West Bengal, India, is a complex ecosystem that contains the most diverse and abundant natural

resources. The SMF is in the south of the Tropic of Cancer, to the northwest of the Bay of Bengal (21°30′-22°30′N, 89°12′- 90°18′ E) (Rahman, Rahman, & Islam, 2010). Dominant plant species of the SMF are *Heritiera fomes* (locally called Sundari, from which *Sundarban* derives its name), *Excoecaria agallocha* (Gewa), *Ceriops decandra* (Goran), *Sonneratia apetala* (Keora) and *Nipa fruticans* (Golpata). Some of the species, particularly *Cynometra ramiflora* (Shingra), *Amoora cuculata* (Latmi) and *Rhizophora mucronate* (Garjan) are threatened due to unregulated felling (Biswas, Choudhury, Nishat, & Rahman, 2007).

The total land area of SMF is 4,143 km², and the remaining water area of 1,874 km² encompasses rivers, small streams, and canals. The existence of the SFM, forming an ideal mangrove ecosystem, supports large groups of fish, shrimp, edible crab, and supplies food and income opportunities to the coastal communities. The forests are being reduced alarmingly day by day due to immense pressure from usage by around 3.5 million people who depend directly or indirectly on the SMF for their livelihood (Shah, Huq, & Rahman, 2010).

The artisanal fisheries contribute around 80-90% to the total marine fisheries production in Bangladesh. In the year 2014-15, about 93% of the catch (515,000 Metric tons) came from the artisanal fishery, whereas only around 7% (84,846 Metric tons) of the marine catches came from the industrial fishery. In the fisheries, different types of fishing gears like gill nets (57.7% of catch), set bag nets (29%), trammel net (2.5%), long lines (6%) and other fishing gears (4.8 %) are used (DoF, 2016). Among these, the Estuarine Set Bag Net (ESBN) is widely employed in the SMF and considered as the most significant fishery with respect to the number used, catch size and species composition as well as the cumulative impacts on the fisheries resources. The catches of the ESBN are mainly juveniles and young fish and other aquatic animals (Rashed & Ullah, 2012). Mechanized boats (usually with the engine of 5-35HP) operate some of these gears, but most country boats are operated manually (Islam & Haque, 2004). For the local population in the Sundarbans, the artisanal fisheries are the predominant type of fishing. Inshore, estuarine and coastal fisheries of the Sundarbans provide a primary source of livelihood for about 200,000 fishers operating daily in the Sundarbans water area (Hoq, 2007).

Over recent decades, the emphasis of development and research initiatives in the fisheries sector of Bangladesh has been on inland freshwater systems. This focus has resulted in a constant lack of management capacity and information regarding coastal and mangrove fisheries, including the SMF. Furthermore, despite the importance of the artisanal fishery to food security, trade, and economic activity, the socio-economic contributions of the SMF artisanal fishers have been undermined politically and historically. Artisanal fishing operations in SMF are considered responsible for overfishing and threatening the mangrove ecosystems (Hoq, 2007). Furthermore, no comprehensive fisheries management system has ever existed in the Sundarbans. Under these conditions, the sustainability and economic viability aspects of the artisanal fishery are considered vulnerable. The artisanal fishery is often thought to be backward due to the shortage of data and understanding of real trends and socio-economic impacts. Such matters have also resulted in a lack of recognition of the value of the Sundarbans fisheries and their current and potential contributions to food security and poverty alleviation in the rural coastal areas. Furthermore, the poor resource users of developing countries over-exploit their environment out of sheer necessity, and the ensuing degradation further aggravates poverty in turn (McGoodwin, 1995). Accordingly, poverty alleviation would automatically reduce environmental degradation and that reducing environmental degradation would alleviate poverty (Reardon & Vosti, 1997). Based on these understandings, the present study focuses on risks and shocks and their relations to poverty and vulnerability. Furthermore, it explores the socio-economic characteristics and fishing activities of the artisanal fishers in the SMF to improve our understandings of the fisheries structure and management practices, and artisanal fishers' livelihood and social wellbeing.

Conceptual Framework

This article is based on theories related to poverty and vulnerability which is used to analyze the empirical data. There is a popular belief that fishers are among the poorest of the poor and small-scale fisheries are indeed equated with poverty (Béné, 2003). Furthermore, poverty in small-scale fisheries is not only the consequence of scarce resources but many other factors as well. Disaggregating the poor fishers into (socially) marginalized, (economically) excluded, (politically) disempowered, and (class) exploited groups, the poverty-fisher model reveals a more holistic range of different mechanisms that lead to insolvency (Béné, 2003). Food is the priority for survival of any individual and notion of poverty was mainly based on the level of income and consumption criteria (Sanchez-Martinez & Davis, 2014). Poverty is not just an inability to meet the minimum nutrition or subsistence needs, rather it includes a more general material deprivation to keep up with a minimal standard of requirements in particular society (Maxwell, 2001). Hence, in addition to the lack of income, poverty was re-conceptualized later as the failure to fulfill the basic requirements such as adequate nutrition, clean water, healthcare, education, housing and other services required to sustain livelihoods (Misturelli & Heffernan, 2010). Fisher's poverty is not a one-dimensional phenomenon, rather

a multidimensional issue with many faces, of which lower income is only one factor (Macfadyen & Corcoran, 2002). Furthermore, poverty is constituted through several other factors such as capabilities (health, education, and nutrition), vulnerabilities, and political empowerment (Thorpe, Andrew, & Allison, 2008). The poor fishers may suffer economic exclusion because of their financial inability to get access to productive assets that are necessary to enter or operate fishing activities. Also, fishers' access to and use of a resource might be systematically denied due to their social status based on caste, gender or ethnic origin (Béné, 2009).

The vulnerability is also linked to poverty, both as a causal factor and a direct product. Furthermore, it entails two distinct dimensions: the exposure to shocks and stresses emanating from both internal and external sources, and individuals' lack of capability to take appropriate measures in the face of risks (Deb & Haque, 2011). Different authors have depicted vulnerability in a variety of ways. In fisheries, vulnerability is perceived of as an essential dimension of fisher's poverty (Béné, 2009). When people are poor, they are also less resilient. They do not easily recover from shocks or crises. Any further shocks or crises such as a bad fish harvest, illness of the family head, financial asset loss, etc. may easily push them into extreme poverty cycle (Islam, 2011). Also, fishing communities are vulnerable in different ways, so that the poorest tend to be disadvantaged in receiving food and financial help to rebuild their livelihood (Thorpe *et al.*, 2008). The vulnerability is not synonymous to risk; both the concepts are related. While risk is about exposure to external hazard over which people have no or limited control, vulnerability conceptually includes the capacity to manage such risks without suffering a damaging or socially unacceptable loss of well-being (Chambers, 2006). Furthermore, it is a dynamic process, and people move in and out of poverty due to vulnerability (Glewwe & Hall, 1998).

Study Areas and Methods

The study was conducted with two artisanal fishing communities (Figure 1) living in Bamna Nil Dumor village (Burigoalini Union [1]; Shyamnagar Upazilla [1] of Sathkira district) and Joymunir Gul (Chila Union, Mongla upazilla under the district of Bagerhat). For the simplicity in description henceforth, these two study sites will be mentioned as site 1 and site 2 respectively. The two study sites are around 100 km far from each other, and both are located on the edge of the Sundarbans mangrove forest. Around nine thousand people comprised of both low caste Hindu and Muslims live in these villages and mostly rely on the extraction of common pool resources for their livelihoods.

This study used both primary and secondary data. For empirical evidence, fieldworks were conducted lasting four months (November 2013-February 2014) through participatory observation, individual and key informant interviews, and Focus Group Discussions (FGD). Interviews were conducted using a semi-structured questionnaire, consisting of questions regarding household characteristics, possessions and productive assets, extractions of mangrove forest resources, target species and gear used, risk perception, risks and shocks faced during fishing and in daily life, and coping strategies against sets of vulnerabilities. In total, seventy interviews were concluded, fifty of which were with fishers (men 40 and women 10). The rest were with people involved in post-harvest activities and credit markets, some forest officials and Non-Governmental Organization (NGO) officials. Each interview lasted about 40-50 minutes on average, and prior consent was ensured before tape-recording of the interviews.

Two FGDs were conducted in the two study villages together with the local people, resource harvesters or extractors like woodcutters, fishers, shrimp fry collectors, day laborers, marginal businesspeople, landless and rural elites from the SMF. Such discussions helped to determine their household livelihoods and resource profiles, vulnerability sources, seasonality of crop production or fishing, migration trends, profession changes, social categories and strategies, trends in resource use patterns during natural calamities, and linkages with government agencies and NGOs. Additionally, ten key informant interviews were conducted with some knowledgeable persons (heads of the society and NGO officials) to validate the information. Supplementary to the interviews, secondary data were collected from daily newspapers, and reports published by NGOs working with the small-scale fishers of the coastal areas of Bangladesh. These secondary data are particularly useful in providing information about illegal and unlawful activities that take place in the Sundarbans. All the interviews were transcribed. Furthermore, collected data were entered into a database system, then contents were analyzed, and themes were identified and classified into different groups.

Results

Socio-Economic Characteristics

A total of more than nine thousand people lives in the study areas. The gender distribution of household heads of all sample respondents was predominantly male in both study areas (83% in site 1, and 93% in site 2). Though female household heads were less in two locations, their numbers were higher at site 1 (17%) compared to site 2 (7%) (Table 1). This indicates the prevailing trends of gender issues in being a household head. During FGD in site 1, one female respondent (Fatema, age 28) described how she became household head:

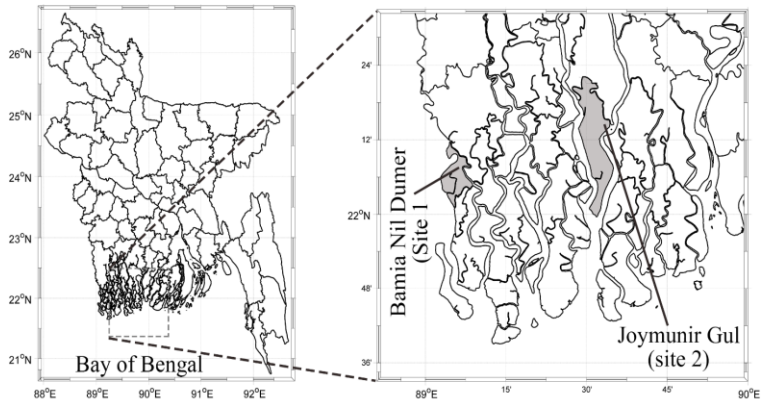

Figure 1. Map of Bangladesh where the study areas and some adjacent areas are marked by rectangles which is projected at the right image. In the projected area, the locations of two study sites are indicated by arrows.

Table 1. Short summary (in percentage) of the key demographic and other factors in study sites

Variables	% in site 1	% in site 2
Male	83	93
Female	17	7
Age class (31-40 years)	32	37
Family size (4-6 members)	56	67
Illiterate	29	25
Literate	43	23
Nipa fruticans ('Golpata') leaves cutting (secondary occupation)	13	20
Fuel wood collection (secondary occupation)	17	15
No fishing boat	25	21
Fishing net range (3-4)	50	27
Uses of mangrove resources (daily)	37	33
House condition (hut made of *Nipa fruticans* leaves)	66	56

"I got married at the age of 16. My husband's main occupation was fishing near the mangrove areas of Bamia Nil Dumor and surrounding areas. We were passing happy life with his income. Suddenly, he died due to illness since I did not have enough money to continue his medical treatment. All my savings were used up for his treatment. My sons were not old enough to go for fishing. Finally, I decided to go for fishing myself and collect shrimp fry from the wild to survive.

Most of the respondents in both study areas are in between 31 and 40 years age and fit for the labor market as well as fishing to earn their livelihoods. A big family size is one of the most common features of a fishing community. The household size composition is related to occupation and income, and is likely to exert significant influence on household livelihood activities. The average family size is around 5 in both the sites (Table 1). However, nuclear (sons and daughters are separated from the parents, and they maintain their own family) and extended (parents, sons, and daughters live in the same household) family types were found in both study sites. In the extended family, most of the members go for fishing, and they can extract more resources from nearby rivers as well as from the mangrove forest. On the contrary, single type family failed to extract many resources from the forest owing to few members.

Education

In most fishing hamlets, there were no schools; even the nearest schools were inaccessible due to very long distance or poor road communication (site 2). Illiteracy was widespread among elders, and this was also common among their children. Also, child labour was quite common among fishers. If a child had been to school, it was most likely that he/she would fail to complete primary schooling due to educational expenses incurred; also, children's contribution to meet the demand of the family to support household income would be compromised. In the words of a respondent (Rafiq, Age 45, Joymunir Gul):

"I know that supporting the education of children is a good thing. But due to poverty, I should engage my kids in fishing as I need helping hands for fishing. If I hire another person to go with me, I must pay wage even if I do not get any catch (crab). For example, today we three (me, my child and wife) have earned only Taka 200 (equivalent to around € 2 during the period of the interview) for the whole day fishing. If I would send my child to school and hired a person instead of him, then I had to pay at least Taka 100 (€ 1) as one-day wage. Is it possible to maintain

my family of 6 members with Taka 100 (€ 1) for one day? Firstly, we must survive, and then the question of education comes."

Fishing Operations

Fishermen's access to the fishing ground mainly depends on ownership of fishing boats. 25% and 21 % respondents in site 1 and site 2 lacked ownership overfishing crafts respectively, meaning that their mobility for fishing remained restricted to shallow inshore waters (Table 1). Nevertheless, these fishers worked with other fishers (nearest kin, neighbors or friends in the community) who shared their boats or worked as a daily labourer, the only way to access the fishing ground. One Fisherman (Karim Mia, Age 47) from Bamia Nil Dumor (site 1) said:

"As a full-time fisherman, I also wish to have my boats and fishing gears. Even if the income flow is erratic and small, for as long as it can provide the basic needs of my family, food, and clothing, that's enough for me. However, we don't have the required capital for the boats to buy. Even dadonder (moneylender) do not want to give us a loan during the lean period as we do not have boats."

We observed that lack of basic endowment sets needed for artisanal fishing hinders the capability of a group of fishers to be engaged fully into the profession. For many of them, economic problems that existed and perpetuated for this category of ultra-poor has festered and grown out of proportion.

Socio-Economic Diversification

Primary livelihoods of the respondents in both the sites were active fishing and fishing related ancillary businesses like fry transportation and trading. Though the income from fishing only is not sufficient for them, SMF offers a different scope for alternative livelihoods. Most of the respondents go for the subsequent occupation to compensate the small income from fishing. Alternative livelihoods in the study areas were agriculture, crab collection, shrimp fry collection, and *Nipa fruticans* leaves harvesting, fuel wood gathering, labor and boat making. However, *Nipa fruticans* leave and fuel wood collection from SMF was given preference as subsequent occupation by the respondents in both sites (Table 1).

Biodiversity and Gears Used

Sundarban has rich diversity of aquatic and terrestrial flora and fauna. There were about 334 plant species, including 35 legumes, 29 grasses, 19 sedges and 50 true mangrove plant species (Chaffey, Miller, & Sandom, 1995). The fish fauna of the Bangladesh Sundarban includes 53 pelagic and 124 demersal species (Sarker, 1989). Among the invertebrates some molluscs and crustaceans constitute important fisheries resources. About 20 species of shrimps, 8 species of lobsters, 7 species of crabs, several species of gastropods, and 6 species of pelecypods have been reported from the Sundarbans (Pasha & Siddiqui, 2003). Among the shrimps *Penaeus monodon*, *Metapenaeus monoceros* and the mud crab *Scylla serrata* are commercially important. In this study, respondents identified several important fishes in the adjacent rivers and mangroves areas. These were: Golda (*Macrobracium rosenbergii)*, Bagda (*Penaeus monodon*), Koi (*Anabas testudineus*), Shoal (*Channa striata*), Magur (*Clarias batrachu*s), Tengra (*Mystus bleekeri*), Ilish *(Hilsa ilisha)*, Vetki (*Lates calcarifer*), Datina *(Acanthopagrus latus)*, and Pangus *(Pangasius pangasius)*. For causes of fish and shrimp availability in the mangroves area, most of the interviewees stated that mangroves play an important role regarding breeding and nursing of aquatic animals.

There were 14 different fishing methods and gears used by the fisherman inside the Sundarbans. These were clustered into three major groups based on target species and fishing gear: 1) Single species-single gear fisheries- A single primary type of fishing gear takes most of the total catch of a single target species. Other gears take only small quantities of the target species. Bycatch of other species by primary gears tends to be minor. Examples include the gillnet fishery for Hilsa (*Tenualosa ilisha*), longlines for mud crab, longlines for prawns, and pull, push and set bag nets for shrimp post larvae and oyster fisheries. 2) Single species-multi gear fisheries- A gear generally targets a single species, but significant quantities of these target species are also taken by other gear. Examples include gillnet fisheries for fatty cat fish and sea bass. 3) Multi species-Single gear fisheries- Single gears tend to be nonselective, and take many species, e.g. set bag net, cast net, long line, gill net, shore net, canal gill net, shore seine (Haque, 2003). In this study, there were five different types of gillnets (i.e. drift gillnet, fixed gill net, large mesh gillnet, bottom set gillnet and mullet gillnet), and two types of set bag nets (estuarine and marine set bag nets) mostly used on both sites. Nevertheless, fishers in both sites used the same types of fishing nets. Most commonly used nets were: *Basan Jal* (gill net), *Jhaki Jal* (cast net), *Ponamara Jal* (push net of set bag net character), *Keoa Jal*, *Tana Jal* (push net / dragnet) whereas in site 2 they used *Chorpata*, *Behundi Jal* (estuarine set bag net), *Ilish Jal* (gill net), *Tana Jal*, and *Khalpata*. In the present study, shrimp fry fishing by using set bag net was found highly damaging to biodiversity and wild fish stocks.

Income for Livelihoods

In FGD, respondents in both sites stated that their earnings increased (attributed to an increase in price of fish, not for an increase in catch per unit effort *per se*), compared to the previous years, but their livelihood wellbeing did not improve due to the

seasonality of the profession. Furthermore, more people get engaged in fishing (especially shrimp larva/fry fishing) as the occupation of the last resort following bans on wood cutting by the Forest Department, price hike of fishes and daily necessities, inherent poverty, and lack of alternative employments among others. A Crab collector (Sultan Mia, Age 55) from site 1 said that:

"I have seven family members. Earlier, when I caught crabs, I always let the juvenile crabs free. But now sizable crabs are dwindling. My current average income is around Taka 195 /day (€ 2). Therefore, now I don't allow young crabs back to water. I retain them and thus supplement our daily food. We know that we are destroying our future livelihoods through this practice, but I have no other choices."

Also, respondents in both sites stated that the reduction of fish catches was greater than ever before. The respondents identified the fundamental causes of fish reduction in their discussion as the increased number of fishers, use of poisons (by spreading poisonous liquid chemicals in the canals) for fishing, siltation, etc. Moreover, small-scale fishers were catching more juveniles of fish and crabs by reducing the mesh size of nets.

Extra Costs Incurred in Fishing Operations

For fishing in the SMF areas, some causes are responsible for increasing the overhead cost of fishing, and fishers must compensate the loss by increasing fishing pressure by any means, legally and illegally. Furthermore, forest department officials take a bribe from the fishers and allow them for illegal fishing and illegal cutting of mangroves. Though, the respondents compensate the loss by extracting more resources from the SMF. Such things were evident during the group discussion in Site 2, fishers (Fozol Mia 48, Joynal 40 and Sajib Das 35) mentioned:

"We are fishers in the Chadpai range of Sundarban. We must collect a permit for fishing by paying a certain amount of fees. But permit issuing fisheries officials always charge extra money. Our income for fishing per week is about Taka 1000 (€ 10) per person. So, we must have some savings for paying the customary fees as well as the extra money charged by civil servants. But in the Sundarbans area, there are some active illegal elements. They divide the total area into different zones for collecting extortion. We must pay Taka 500 (€ 5) per week as extortion. Moreover, some corrupt forest officials also charge extra money during fishing. In this way, most of our incomes go into the pockets of others. But we must survive. So, we compensate our loss by catching more fish than limited by the permits; keep those hidden under the deck of our boat."

Mangroves Resources for Making Livelihoods

The mangrove resources for identified for generating livelihood opportunities in the studied areas were: firewood for household consumption or small-scale marketing, poles and mangrove leaves (especially leaves of *Nipa fruticans*) for housing and boat construction, prawns, fishes and crabs for household uses or for selling. Most of the respondents (33% in site 2 and 37% in site 1) used mangrove resources daily (Table 1) and manifested their dependency on mangroves resources for making livelihoods. The roofs of most of the houses were made of *Nipa fruticans* leaves (Golpata), 66% in site 1 and 56% in site 2 (Table 1). During the FGD in both the study sites, deforestation of mangroves was discussed. Respondents stated that illegal logging and household consumption in the face of population growth were the main causes of mangrove deforestation in the SMS. Also, climate change issues manifested in the form higher temperature and higher salinity in the SMF rivers, anthropogenic disturbances like shrimp farming, natural disasters (cyclones and flooding) were responsible for the deterioration of mangroves in the SMF. One respondent (Ripon Das 45) in site 2 expressed his ideas as:

"Twenty years ago, I could catch more than 5 kg different types of fishes within 6 hours from fishing in the Chilla River. Besides fishing, sometimes I went to catch crabs also in nearby mangroves and was happy with the amount of catch. But now I cannot get enough fish or crabs that are sufficient for my livelihoods. I do not know why it is happening and how I will survive. I might change my occupation rather than continuing fishing."

The reduction in mangroves forest, as well as mangroves inundated area, has a negative impact on the artisanal fishermen's livelihoods. All the respondents in both study sites mentioned that their present occupation (fishing) was hampered through the continued destruction of mangrove forest. The consequences were less fish and fishery resources, livelihood changes, changes in fishermen's profession, and finally a sharp decline in fish harvest in the last few years.

Risk and Vulnerability

During the FGD in both study sites, different types of risks and vulnerabilities were discussed by the artisanal fishers that they faced while fishing in the SMF. Fishers identified fishing in the SMF to be risky, as tiger-human conflicts claim fishers' lives and affected the livelihoods of their family members. Furthermore, fishers were afraid of being assaulted and concerned that dacoits would snatch their boat or nets. Also, when disasters strike as a form of cyclones, the loss of fishing gears, boats, livestock, and other household assets can dramatically impact entire livelihoods. At that point, families would have to rebuild their lives and livelihoods from scratch. Moreover, the death of a household member, capable of working, can bring the whole family into extreme poverty and extended trauma.

Coping Strategies

Artisanal fishers of SMF adopted different strategies to cope with the current changes. Fishing families in the SMF areas first cope with vulnerability through family cooperation; then they enter into partnerships with other fishers to increase the production as well as safety, often through violating existing fisheries management laws and regulations, thus exerting more demographic pressure on the resources. Besides, when fish catches even after applying excessive fishing pressures were not sufficient to survive, the artisanal fishermen in the study areas prefer to change their primary occupation for a short period. The alternative livelihoods were boat making, netting, agriculture and wage labour, etc. The reduction in the fishermen's income was often compensated by the role of women in livelihood strategies. Women in SMF supplement the household income by collecting firewood, catching shrimp fry in the nearby rivers, and working in the aquaculture farms. Fishers in both sites shared their knowledge and exchanged information to solve problems for dependency related with the profession. In the case of solving problems linked with occupation, fishermen discussed the matter with family members, neighbors, heads of the society, learned persons, friends and NGO officers. Nevertheless, the fishermen wanted to change their livelihood strategies. In this study, one of the respondant (Gofur Mia 60) in site 2 expressed his wishes as follows:

"I have been a fisherman for 30 years. See, my life is going nowhere. I catch fish in the river, sell them in the market and buy food for my family. I am staying in the same house that I got from my father, made of mud. I want to improve my living condition. I want my child to be educated and to get a good job. I do not want my kids to be a fisherman and to lead the life that I am living now."

Discussion

Sundarbans are the world's largest Mangrove biomes having highest mangrove biodiversity, which are used for subsistence and commercial purpose by the local inhabitants. It is one of the essential components of the livelihood of the forest dependent population of the area (Singh, Bhattacharya, Vyas, & Roy, 2010). The open access nature of coastal fisheries encourages inclination towards larger family, as an increase in family members can enhance income for livelihood support through additional extraction of resource benefits. The average family size is around 5 in both study sites. Rouf and Jenson (2001) also found larger family size (5-6 family members) in the Joymunir Gul village (site 2) that mostly depend on fishing, particularly shrimp fry collection. In this study, the primary livelihoods of the respondents in both sites are active fishing and fishing related subsidiary businesses like fry transportation and trading. Nevertheless, in the SMF areas, households have multiple livelihood activities that include: salt production, fishing (coastal and marine), fish processing (drying), net making, fry collection, shrimp farming, crab/shellfish gathering, extraction of forest products (wood, honey, leaves of *Nipa fruticans* and wax collection); and boat building (Huntington, Khan, Islam, Brakel, & Miller, 2007).

Different types of nets are used in the study sites for fishing. Trammel net, bottom long lines, beach seine and many other nets are also used throughout the coast and estuaries (Huntington *et al.*, 2007). Most of the fishing communities in SMF are involved with inshore fishing particularly for shrimp fry collection by using set bag nets (SBNs) and Dragnet. SBN is used by male fishers inside the SMF area, while dragnets are predominantly used by children and women fishers. The present study also revealed the extensive use of set bag nets in both study sites. Set bag nets are known to be highly damaging to biodiversity and wild fish stocks, particularly, the fixed bag nets. It has been reported that about 99 fin fish and other prawn species fry are discarded for collecting a single shrimp larva (Rashid, 2000; Ahamed, Hossain, Fulanda, Ahmed, & Ohtomi, 2012) which is a significant threat to the biodiversity. Furthermore, nearshore fisheries areas of the Sundarbans ecosystem are believed to be overexploited. The reason for this overexploitation is the extensive use of destructive set bag nets for extensive shrimp fry collection. It is one of the major threats to the coastal ecosystem, causing damage to the nursery grounds of many species, and to newly planted mangroves as well as reserve forests (Hoq, 2000).

Usually, households in mangrove areas depend directly on mangrove forests for fish and wood collection. Mangrove loss, therefore, affects the decision of families to look for outside employment (Barbier, 2006). Lack of job opportunities and income alternatives for young people and women are the initial economic problems. The shortage of job intensifies mangrove resources exploitation as the only option for subsistence and financial income and leads to a more widespread and intensive mangrove dependence. This dependence is nowadays a great concern for villagers as they perceive a decrease in the availability of mangrove resources (Fontalvo, Glaser, & Ribeiro, 2007). Also, the increased population with few alternative livelihood opportunities poses a serious threat to the Sundarbans as it is the main cause of mangrove destruction (Ong, 1995; Ali, Kabir, & Hoque, 2006). This research also shows such type of dependency as most of the respondents used mangrove resources daily, which may be one of the main reasons for mangrove deforestation. Likewise, fishers opine that mangroves territories are decreasing due to shrimp farming in the SMF and adjacent areas. Although shrimp farming

provides immediate economic benefits, contributes to poverty reduction and food security, as well as generates employment from seed collectors to exporters, it has also been facing a host of challenges (Paul & Vogl, 2011). In Bangladesh, mangrove wetlands are still being converted to ponds for shrimp aquaculture (Deb, 1998; Chowdhury, Shivakoti, & Salequzzaman, 2006). Destruction of mangroves due to shrimp aquaculture has been reported by several scholars in different parts of the world (Primavera, 1997). Impacts of shrimp farming on both lands (i.e., mangrove forests) and people became apparent worldwide (Joffre *et al*., 2015). These effects include reduced area of habitat for thousands of species, reduced availability of land and forest goods (i.e., agriculture, food, fuel, medicine), nursery and fishery collapse, decreased water quality, loss of protective coastal barrier, decreased shoreline stabilization and land building (Islam, Milstein, Wahab, Kamal, & Dewan, 2005; Joffre *et al*., 2015).

For sustainable human resources development, education is an essential prerequisite. It plays a significant role in improving productivity at individual and community levels, equipping people with skills and knowledge to enhance economic development and to promote entrepreneurship (Rainey, Robinson, Allen, & Christy, 2003). Coastal fishers of Bangladesh are relatively isolated because they are living along the narrow margins of rivers and the sea. This relative isolation is increased by their separation from land-based society while fishing. Also, many fishing people work at night or early in the morning when most are asleep. Social exclusion may inhibit their access to formal education (Azad & Haque, 2003). Rabbani and Sarker (1997) reported that 22% of the fishers of Sundarban Reserve Forest (SRF) areas can write only their name and only 16% can read and write. Chantarasri (1994) found that a significant number of younger male and female (less than 15 years) were involved with fishing activities. In similar vein, a survey in Patuakhali and Barguna districts revealed that about 50% of school going children do not participate in class during the peak season (February- May) of shrimp seeds collection (Azad, 2002). Most fishers in the area, as well as the study respondents have a low level of education, and the child labour is a common phenomenon. Completion of primary or higher secondary education does not necessarily help ensuring a job in Bangladesh due to high unemployment rate. Moreover, as members with low social statues (low caste), fishers are often deprived of equal opportunities. Furthermore, lack of education undermines skill and the ability of the fishers and makes them unaware of sanitation practices increasing the likelihood of diseases and illness (Islam, 2008).

Small-scale fishing communities are often characterized as being amongst a poor socio-economic group in developing countries (Jazairy, Alamgir, & Panuccio, 1992) and interventions targeted at improving resource status seem as central in the fight against poverty (Jazairy, Alamgir, & Panuccio, 2011). This view, which is commonly accepted in the fisheries literature (Be´ne´, 2003), conveys the idea of a structural, chronic poverty. Other authors highlight the high vulnerability of fisher folks instead, partially due to their high exposure to certain natural, health related or economic shocks and disasters (Allison *et al*., 2009). Vulnerability and risk are inseparable parts of fishing in the Bay of Bengal and the adjacent areas of the SMF. Cyclones and tropical storms are annual phenomena. Also, the tidal activity is becoming increasingly choppy, making fishing operations dangerous and limited. Rough seas, as well as frequent cyclones, often force artisanal fishers to stay home or to abandon their fishing trip. Many fishers rebel warnings and continue fishing, which results in many fatalities every year. For instance, during cyclone Sidr in 2007, many fishers died as they ignored the cautionary signal of a cyclone (Islam, 2011). Also, fishers are exposed to piracy while at sea, which is particularly severe during the Hilsha fishing season, and in the case of the Sundarbans, all the year round (Islam, 2011). Income from risky fishing in the Sundarbans is further dissipated (mostly illegally) by rent-seeking activities of different levels from fishing to marketing. Such stories are spoken during the FGD in both study sites.

Coping strategies are often complex and diverse and encompass measures and mechanisms both within the fisheries sector and outside. According to Salgrama (2006), coping strategies adopted by fishers are strategies for enhancing their current livelihood systems, diversification into other occupations (whether at the individual level seasonally, or at the household level, where different members work in various activities) and a complete shift to a new business. In this regard, the artisanal fishermen of SMF adopted different strategies to cope with the changing conditions by forming associations, violating the fisheries laws and regulations, migrating, sharing responsibilities with the household members, and transmitting local ecological knowledge.

Conclusions

Socio-economic priorities for mangrove villages are, among others, in order of importance, improving the quality of education, increasing occupational options, providing dependable medical care, raising mangrove product prices, providing access to electricity, and improving the quality of local leadership (Glaser, 2003). The mangrove forest and associated fisheries are valuable coastal resources for Bangladesh and have been playing a significant role in the coastal economy of the country. The SMF has been reduced alarmingly, with visible impacts on its fish stocks and fisheries. Over-fishing and over-exploitation of plant and wildlife species are placing

great stress on the viability of this ecosystem. At present, over-fishing is practiced with some species and many others are at risk. Consequences of these changes are affecting the livelihoods of the resource users, especially artisanal fishermen in the SMF. The principles and goals of fisheries management have been changing worldwide over time and with the different needs of the ecosystem and the community. Although there are several management policies in the SMF to protect fisheries and mangroves there, these are not being implemented correctly.

Healthy mangrove systems in Bangladesh not only support meeting the economic needs and fishery resources but also protect lives and properties from natural disasters. The SMF green cover has been standing firm against natural disasters for ages. Its vegetation consists of 64 plant species, which have the capacity to withstand estuarine conditions and saline inundation and can face strong winds (Rahman & Rahman, 2015). Furthermore, The SMF's triple tier natural protection mechanisms protect the islands from cyclonic storms originating in the Bay of Bengal (Miyan, 2012). Hence it is necessary for stakeholders to use SMF resources sustainably. Here are some recommendations for sustainable use of SMF resources, which will eventually improve the socio-economic conditions of the artisanal fishermen in the SMF:

Public support and community participation are the primary requirements of successfully establishing of any system. Hence, adaptive management systems (like community-based fisheries management or co-management) should be developed for better understanding of the social-ecological system of the SMF.

In structuring management systems and policy implementation, socio-economic and cultural heterogeneity should be addressed. Furthermore, attention to the local politics, religion, education level and influence of the local authority on the management plan should be considered, as all these components play direct or indirect roles in policy implementation.

The fisheries managers and other management authorities should have sufficient knowledge of the SMF ecosystem, including fish stocks and fishing household living strategies, to incorporate such knowledge in the process of management planning. They can gain this knowledge by exchanging information with the local artisanal fishermen, who are excellent sources of local ecological knowledge regarding the fishery resources in the SMF, from which they are obtaining their livelihoods. Eventually this will lead to the formulation of a proper management plan.

The demarcation and enforcement of protected areas would be a powerful tool in offshore and marine fisheries' management. Thus far no reports have been published regarding the practice of establishing protected areas in the mangrove fisheries of Bangladesh. However, this can be practiced in the SMF to enhance the management of offshore fisheries and marine fisheries.

Trammel net fishing and the bottom longline fishing can be introduced in the SMF area to reduce the mass use of ESBN systems in this area. This practice can be added as a feasible option to engage fisher folk in more ecologically sustainable fishing systems.

Restriction on fishing during breeding seasons should be strictly implemented by the responsible authorities (Forest and Fisheries Department) in the SMF. During those periods, alternative livelihoods for the fishermen can be arranged by the Government.

Alternative income generating employment should be arranged for women in activities other than shrimp fry gathering.

Law and order functions need to be separated from management roles, and there is a critical need to train forest management officials in how to engage local people in the natural resource management-related decision-making process.

Respondents spoke about the lack of communication and transportation infrastructure in the SMF preventing fishermen from getting a proper price for their catch. They cannot sell their catch in the local market as it is far away from the fishing villages, so they must sell at a low price to a middle man. To address this situation the government should take steps to develop infrastructure systems such as roads, bridges and public transportation in the SMF. Eventually this will improve the living conditions of the fishermen.

Finally, the current sectoral policies in the SMF need reorientation. New policies on land and water use and human settlements should be adopted to ensure institutional coordination. Legislation is required to regulate all negatively impacting activities and to establish protective standards, mitigation, monitoring, and enforcement.

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